Development and Evaluation of Mechanical Test Methods For Composite Materials

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ABSTRACT

The utilization of composite materials as a material of choice for aviation applications has seen tremendous growth over the last several decades. This growth has resulted in a proliferation of both commercial and in-house composite material testing facilities. This research investigation has focused on two tasks that address reoccurring problems in mechanical testing of composite materials. A third task is focusing on the damage tolerance of stitched sandwich composites.

The first task focused on the establishment of proper tabbing configurations and tabbing methods for mechanical testing of composite materials. The selection of a proper tabbing configuration and tab bonding procedure are critical in the testing process since the tabs serve to protect the specimen as well as introduce the load into the specimen. An experimental and numerical investigation was performed to identify optimum materials and configurations for both tension and compression testing. Variables investigated include the tabbing material used, the tab thickness, tab length, tab taper angle, adhesive material, and the adhesive thickness. A detailed Tabbing Guide for Composite Test Specimens was prepared that summarizes the results from this task. This Guide is intended to offer suggestions for selecting suitable tabbing configurations for composite material test specimens. Additionally, a practical methodology is detailed for preparing and applying tabs to composite test specimens.

The second task has focused on developing a V-notched rail shear test for measuring the in-plane shear modulus and shear strength of composite laminates. The determination of shear strength using the current two-rail shear test method is questionable due to stress concentrations produced in the specimen at the rails and at the clamping holes in the rails. If improved, however, this test method is of interest for high shear strength composite laminates since load is introduced through the specimen faces rather than the edges. The two-rail shear test method has many characteristics similar to the Iosipescu V-notched shear test method, and yet these similarities have not been explored. The relatively small gage section of the Iosipescu specimen provides limitations for some textile composites and edge loading of the specimen limits the load that may be applied to the specimen without producing localized failures. The V-notched rail shear test developed in this investigation incorporates attractive features of the existing Iosipescu V-notched and two-rail shear tests. The proposed 3.0 in. x 2.2 in. specimen provides a larger gage section than the existing Iosipescu V-notched specimen. By face-loading the specimen using roughened rails that are clamped onto the specimen, the test fixture provides enhanced loading capability compared to existing test methods. Experimental and numerical investigations have been performed to identify optimum geometries for the test specimen and fixture as well as investigate tabbing and notching. Successful mechanical testing has been performed on composite laminates with fiber orientations ranging from unidirectional (100% 0° plies) to

$[\pm 45]_{4S}$ (100% ±45° plies). Current efforts are focusing on addressing remaining issues for standardization and the preparation of a draft ASTM standard.

The third task is focusing on the use of through-the-thickness stitching to enhance the damage tolerance of foam core sandwich composites. The proposed research on stitched sandwich structures represents a new, innovative application for stitching. Through-the-thickness stitching is proposed to address the problem of facesheet delamination when sandwich composites are subjected to interlaminar tension, shear, or impact loading. Stitched and unstitched composite sandwich panels have been fabricated using carbon fabric facesheets and Kevlar stitching thread. Emphasis has been placed on using the same facesheet material, core thicknesses, specimen sizes, and test method used to assess the damage tolerance of honeycomb core sandwich composites in previous FAA-sponsored research performed recently at Wichita State University. Impact testing has been performed using an instrumented drop-weight impact tester. Damage tolerance is being assessed using Compression After Impact (CAI) testing. CAI strengths will be compared to the non-impacted compression strengths to determine the strength reduction due to impacting. Additionally, results will be compared to those obtained previously in the Wichita State University investigation to compare the damage tolerance of foam core and honeycomb core sandwich composites.